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Method of Operation for Equal Pressure Internal Combustion Engines with Pre-compression of the Combustion Air.

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Internal combustion engines with gradual combustion, i.e. equal pressure internal combustion engines or internal combustion engines have, in the single-stage design which alone is in use, a very economical mode of operation, but the great disadvantage that their performance, compared with other piston engines, is very poor in relation to the dimensions of their cylinders and engine parts. These engines therefore prove to be relatively heavy, and very expensive to produce. Furthermore, because the difficulties peculiar to the internal combustion engines become greater as the cylinder size is increased, and so make the use of cylinders over a certain size impossible, the performance achievable in one cylinder is also therefore relatively poor. High engine performance therefore requires a large number of cylinders, by means of which the cost of the engines is also increased.

These disadvantages are mainly due to the generally high level of compression in one-stage equal pressure internal combustion engines. It is known that the latter compress the combustion air to thirty to forty times its initial tension; this results in a high level of expansion, only low charging of the cylinder (approximately 10 % with a full load) and a low performance in relation to the cylinder size, to the maximum piston and rod pressure occurring, and to the dimensions of the engine parts.

It has already been tried to build equal pressure internal combustion engines as compound engines, with which, similar to with a compound steam engine, the power was distributed in more or less equal parts over two cylinders, and the compression of the combustion air also took place in two stages. In this way, the high level of compression in the combustion cylinder and the resulting disadvantages are avoided. However, in order to have the low pressure cylinder of this type of compound engine also only theoretically yield approximately the same amount of work as the combustion cylinder, the expansion therein must be interrupted at one stage where the combustion gases are still very hot (1000° and over). Consequently, they lose a great deal of heat when being transferred to the waste gas cylinder. Because of this, the compound engine performs so much worse with regard to fuel consumption than a single-stage engine that all of the advantages of the compound arrangement are far out-weighed.

Whereas the disadvantages of generally conventional one-stage internal combustion engines are largely due to excessively high levels of compression in the combustion cylinder, the failure of the compound internal combustion engine is due to a level of compression in its combustion cylinder which is too low. This is because the high temperature of the waste gases of the combustion cylinder, which is the direct cause of inefficiency, results from low levels of expansion and compression. With even distribution of the work over the two cylinders of a compound engine, the result for the combustion cylinder is approximately five- to six-fold compression. For this purpose, if automatic ignition and good combustion are to be achieved, pre-compression of the combustion air must be at 6 to 8 atm.

This invention relates to a method for operating equal pressure internal combustion engines which come in the middle between the currently generally conventional one-stage and the compound method just described. The method consists of the combustion air being subjected to pre-compression of 2 to 4 atm, and a level of compression being used in the combustion cylinder which is

considerably lower than with the generally conventional one-stage equal-pressure internal combustion engines, but at the same time considerably higher then with the previously proposed compound engines. The level of compression can fluctuate between 12 and 20. The high level of compression applies to low pre-compression, and the low level of compression to high pre-compression. Advantageously, the pre-compression and the compression and expansion level in the combustion cylinder is chosen to be of a level such that the working capacity is sufficient to operate the pre-compressor without any additional assistance.

The engine operating according to the new method has in common with the conventional one-stage Diesel engine the advantage that production of all of the useful work falls to the combustion cylinder alone.

It generally concurs with the compound engine described above, as the compression of the combustion air also takes place in two stages, as does generally also the expansion of the combustion gases, in that the waste gases from the combustion cylinder, unless in exceptional cases where their use appears to be of greater benefit for heating, cooking or similar purposes, are used to fully or partially counter the work of the first compression stage of the so-called pre-compression.

However, the internal combustion engine operating according to this method avoids the aforementioned disadvantages of the one-stage and the compound design. This is because the level of compression in the combustion cylinder is low enough so that the performance of the engine, taking into account the chosen pre-compression, is in an appropriate ratio to the cylinder size, to the highest occurring piston and rod pressure, and to the dimensions of the engine parts. On the other hand, the compression, and connected to this, the expansion is so great that the combustion cylinder alone utilizes the fuel such that the efficiency of the apparatus is guaranteed, without an excess of useful work being necessary in the second expansion stage in order to achieve sufficient efficiency of the apparatus.

That the efficiency of the engine operating according to this method matches that of the generally conventional one-stage Diesel engine can be clearly seen if a normal one-stage Diesel engine which sucks in atmospheric air and compresses it for example to 30 atm, is contrasted with an engine with the same displaced volume of the combustion cylinder operating according to the method, and which sucks in air pre-compressed to 2 atm and only has 15-fold compression. Because the maximum pressure in both engines is the same, the dimensions of the engine parts can also be kept the same. The two engines can therefore only be distinguished from one another structurally by the size of the compression chamber which has a somewhat larger volume with this engine. In order to bring the basis for comparison better in line, it is assumed that the pre-compressed air of the engine is pre-heated to such an extent that the same temperature prevails at the end of compression in both machines despite their different levels of compression. As a result of the higher initial temperature of the pre-compressed air, the engine, although it sucks in air with double the level of tension, will not fully take on double the weight of combustion air, but only approximately 1.7 times as much. Furthermore, both engines may also operate with the same relative excess of air, and this means that at the end of combustion, not only the pressure, but also the temperature of the two is also the same, and as a result of this, the cylinder charge at the end of combustion is 1.7 times as great with this engine than with the conventional one-stage Diesel engine. It is known that the size of the cooling cylinder surface when increasing the charge does not increase to the same extent as the charge, because the surface of the cylinder cover and the piston floor remains unchanged in size. Therefore, with the engine operating according to the invention, which as mentioned has a larger charge, relatively less heat passes to the cylinder walls and to the cool water during the combustion period, in the same way as with a steam engine the heat losses caused by the cooling effect of the cylinder walls becomes less percentage-wise as the charge increases.

Furthermore, it is known that the absolute amount of friction losses of a piston engine is more or less independent of the charge. With this engine it is therefore of approximately the same level as with the Diesel engine. Because, however, the latter develops more power corresponding to its greater quantity of air, its friction losses are considerably lower percentage-wise.

The cool air losses and the friction losses are relatively high (1/3 of the heat expended and 1/4 to 1/5 of the indicated power) with the Diesel engine of conventional design. A reduction of these losses is therefore of great significance for the efficiency of the engine. It becomes clear from this that with the characterized method, despite its low level of compression the combustion cylinder does not utilize the fuel any more poorly than do Diesel engines of conventional design, and also that the unfavourable ratio between the performance and the dimensions of the one-stage internal combustion engine is eliminated. This is because with the same displaced volume and the same dimensions of the engine parts, the engine produces approximately 1.7 times as much power as the engine operating according to the one-stage Diesel method.

The fact that despite its considerably greater power it does not have higher piston and rod pressure, and therefore does not require any stronger engine parts than the comparatively used conventional one-stage Diesel engine, is a result purely of the lower level of compression. The fact that, apart from the compression chamber, it does not require any greater dimensions of the combustion cylinder, is a result of the pre-compression. The specified pre-compression of the combustion air suffices on its own, however, i.e. without at the same time using the specified level of compression in the combustion cylinder, not, in order to achieve the desired target. It is not sufficient either to only choose the level of compression in the combustion cylinder according to the details of the invention, without at the same time using the specified pre-compression.

By means of the level of expansion of the combustion cylinder produced with the method, the combustion gases are cooled down in this cylinder to such an

extent that when transferred, they lose less heat than with a compound internal combustion engine.

Combustion pressures higher than those which are conventional nowadays can, however, also be used advantageously. For example, a pre-compression of 3 atm can be combined with a compression level of 15, and this results in combustion pressure of 45 atm. As well as a further reduction in size of the cylinder, this also improves combustion. This is because the more strongly the combustion air is compressed, the more quickly and the more certainly each particle of the fuel introduced finds the quantity of oxygen necessary for its combustion.

The final compression temperature that one strives for is that which is required for certain self-ignition of the fuel. In general, this is achieved in the combustion cylinder despite the low level of compression because the air undergoes pre-heating by the pre-compression. In cases where this pre-heating is insufficient, the air is further heated artificially before it enters into the combustion cylinder. In cases where the pre-compression and the level of compression are chosen such that a higher final compression temperature is achieved than is necessary for certain ignition, it is advantageous to discharge part of the pre-compression heat during or after the pre-compression so that the greatest possible air weight can be introduced into the combustion cylinder. Of course it would also be feasible to discharge all of the pre-compression heat by cooling. Ignition of the fuel would then have to happen artificially.

The work requirement necessary for pre-compression of the combustion air is not insubstantial. It is therefore significant for the method that the pre-compression work falls as little as possible or not at all to the working process of the actual internal combustion engine. For this reason, as already mentioned above, the waste gases from the combustion cylinder are used for the output of the pre-compression work unless for example in exceptional cases a more advantageous use of the same is possible, and they are supplied to a caloric engine (piston engine or turbine) which drives the pre-compressor (piston or

turbo compressor). With this method, due to the lower level of compression and expansion, the waste gases of the combustion cylinder have a considerably greater work capacity than with internal combustion engines which operate with a level of compression normal with one-stage equal pressure internal combustion engines, and this makes their utilization in a caloric engine cost-effective, especially with two-stroke engines with which the temperature of the exhaust gases from the combustion cylinder is reduced to a relatively large degree due to the necessary excess of scavenge air. On the other hand, the temperature of the waste gases is low enough in order to abstain from artificial cooling of the overflow ducts etc. The pre-compression and the level of compression can be chosen within the value limits characterising the method such that the pre-compressor can be operated without additional assistance. It is also possible in this case to design the pre-compression apparatus as a self-sufficient engine independent of the shaft of the internal combustion engine, and to use a common pre-compression apparatus for a number of internal combustion engines.

As can be clearly seen, the method is suitable for all equal pressure internal combustion engines, but is of particular significance for two-stroke engines because with these, a compressor unit is already available which only needs to be designed according to the ratios of the method.

PATENT CLAIM:

A method of operation for equal pressure internal combustion engines with pre-compression of the combustion air, characterized in that the combustion air is pre-compressed to 2 to 4 atm, and in the combustion cylinder the level of compression is raised to 12 to 20-fold.